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TEA RESEARCH INSTITUTE

OF CEYLON

THE TEA RESEARCH INSTITUTE,
St. Coombs, Talawakelle,
Ceylon.

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Erratum.

Page 91, Table 5. Col. 3 (No. of bulking chambers),
For "1," in the bottom line, read "2."

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VEGETATIVE PROPAGATION AND CLONAL SEED PRODUCTION

G. B. Portsmouth

The question is often asked why the Tea Research Institute does not favour the development of improved strains of seed for planting purposes, but prefers to concentrate entirely on vegetative propagation. The answer is unfortunately by no means simple and, for its proper understanding, some knowledge of the elementary principle of genetics is required.

However, at the outset of this article, it may be as well to point out that Dr. Wight, who is in charge of the breeding work at Tocklai, insists on a clear distinction being made between vegetative and generative clones. Vegetative clones are those used solely for the multiplication of planting material by means of cuttings. Generative clones, on the other hand, are plants which are crossed sexually to produce clonal seed.

Selection and assessment of the characteristics of a vegetative clone is a comparatively straight-forward business, which requires no knowledge of the genetic make up of the plant. Furthermore, under Ceylon conditions, it is a process which is assured of a reasonable degree of success after only a few years. The development of high yielding high quality clones, such as 2024, to a stage at which fairly wide-spread distribution is possible, in the period elapsing since the start of selection work at the Tea Research Institute in 1937, furnishes all the proof necessary for this assertion.

The selection of generative clones, however, is a much more difficult business since it requires an understanding of genetics such as is only likely to be possessed by a specialist plant breeder. Furthermore two selected parents are required to produce each batch of clonal seed, while the assessment of the characteristics of the progeny is much slower than in the case of a vegetative clone. As a consequence it is not surprising that very little in the way of high class clonal seed development has resulted from over twenty years of work at Tocklai.

In fact the difficulties and length of time involved in the development of improved clonal seed with tree crops are so great that this method of improving the standard of planting material has been almost entirely discarded. R. J. Garner, the world famous authority on propagation, in the introduction to the 'Imperial Bureau of Horticulture and Plantation Crops' Technical Communication No. 14, dealing with propagation by cuttings and layers, states:—

> 'In an orderly world the unpredictable variability of seedling plants will not much longer be tolerated. The use of clonal scion varieties is recognised as essential and recent work with fruit tree rootstocks and with 'strains' of small fruits and other subjects grown on their own roots has made clear the

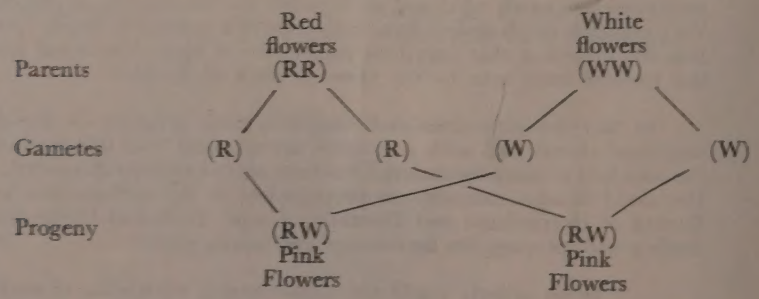
advantages to be gained by the use of selected varieties propagated vegetatively. In years to come it seems likely that we shall insist on having all our woody and many of our herbaceous plants vegetatively propagated including perhaps forest trees and hedge plants'.

Now what are these difficulties which render the production of improved clonal seed such a remote possibility that its successful achievement can be disregarded for all practical purposes. Apart from the fact that the tea bush is sterile to its own pollen, thus rendering breeding work more complicated, the principal difficulty is concerned with the nature of the hereditary mechanisms involved in the concept called 'vigour'. All high yielding, strong growing vegetative clones almost certainly possess vigour in this genetic sense and it is therefore essential that plants produced from clonal seed must also possess vigour if they are to be able to compete on level terms with the better vegetative clones. Unfortunately, it is just this production of vigour which turns out to be one of the most difficult tasks in plant breeding.

In plants all the individual characteristics displayed by any particular species or variety are controlled by certain entities known as genes. Thus in tea we may have separate genes for flower colour, leaf colour, leaf shape, leaf hairiness, type of root development, resistance to blister blight, etc., etc. These genes are present in all cell nuclei, where they are located in bodies known as chromosomes, so called from the readiness with which they can be stained by certain dyes. Each chromosome carries a large number of different genes and, as the tea plant possesses a total of some 30 chromosomes, it is obvious what a vast number of different genetic characters may be involved.

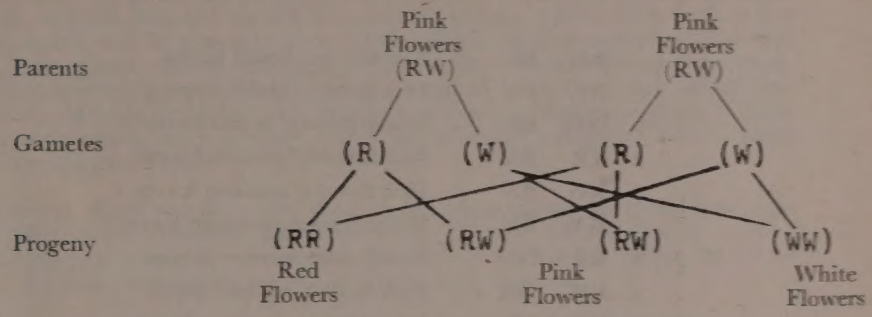
However, in the nucleus of the ordinary vegetative or diploid cell the chromosomes are organised in pairs, each individual of a pair carrying a set of genes controlling the same characters. Thus, if we consider a character such as flower colour, there will be a gene for flower colour in each chromosome of the pair. These two genes may either be the same or different, with the result that different flower colours are possible, depending on the particular genetic constitution of the individual concerned.

When sexual division takes place one chromosome of each pair goes to a different gamete, with the consequence that a new distribution of genes takes place. A simple example will illustrate best what actually happens. The flower *Mirabilis jalapa* has both a red and a white flowered variety. When these are crossed the resulting progeny have pink flowers. Let the gene for red flowers be R, and that for white flowers W. Then the distribution of genes during the process of crossing can be shown diagramatically as under:—



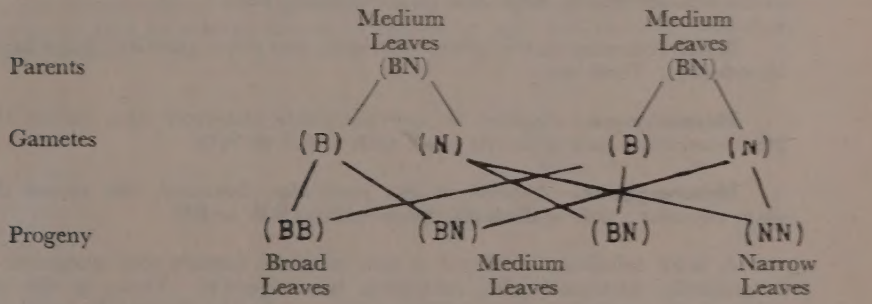
In this case it is evident that when both genes of the pair are the same we get either a red or a white flower, but when they are dissimilar we get pink flowers.

Now let us see what happens when two pink flowered plants are crossed:—



The progeny now contains different coloured plants in the proportion of 1 red, 2 pink and 1 white.

So much for one pair of genes. Suppose now we consider another pair controlling leaf shape. Let the gene for broad leaves be B and that for narrow leaves N, and let plants containing both B and N have medium leaves. Then, provided that they are carried in a different pair of chromosomes from those carrying R and W, these genes will also segregate entirely independantly as under:—



The actual distribution of both sets of genes and the characters to be expected in the progeny can be determined by combining the distributions of both R and W and B and N in a table as under:—

	RR	RW	RW	WW
BB	RR BB	RW BB	RW BB	WW BB
BN	RR BN	RW BN	RW BN	WW BN
BN	RR BN	RW BN	RW BN	WW BN
NN	RR NN	RW NN	RW NN	WW NN

This gives the following proportional expectation of different types of plants in the progeny:—

1	RR	BB	—	Red flowers, broad leaves
2	RW	BB	—	Pink flowers, broad leaves
1	WW	BB	—	White flowers, broad leaves
2	RR	BN	—	Red flowers, medium leaves
4	RW	BN	—	Pink flowers, medium leaves
2	WW	BN	—	White flowers, medium leaves
1	RR	NN	—	Red flowers, narrow leaves
2	RW	NN	—	Pink flowers, narrow leaves
1	WW	NN	—	White flowers, narrow leaves

Thus when only 2 pairs of genes segregate independantly it is possible to get as many as 9 different types of plants in the progeny of a cross. With 3 pairs of genes there is a possibility of 27 different types of progeny and with n different pairs of genes the number will be 3^n.

The 15 pairs of chromosomes in tea would permit of 15 pairs of genes segregating entirely independantly. This could give rise to 3^{15} or 387, 420, 489 different kinds of plant. It is obvious therefore that all the many variations of jat etc. met with in the field are readily explicable on a hereditary basis.

Before returning to the subject of vigour two other genetical terms need to be introduced. These are:—

Homozygous.—Applied to one particular character, this means that the plant contains a pair of similar genes such as RR or WW.

Heterozygous.—Applied to one particular character, this means that the plant contains a pair of dissimilar genes such as RW or BN.

A brief definition of vigour is now possible, namely that maximum vigour is generally associated with maximum heterozygosity. Thus, in the example given above, maximum vigour is likely to be exhibited by the pink flowered, medium leaved plants carrying the dissimilar pairs of genes RW and BN. On the other hand the pure homozygous plants RR BB, RR NN, WW BB and WW NN are likely to be the least vigorous.

Now the fact that our best vegetative clones almost certainly possess a high degree of vigour also implies that their genetic make up is highly heterozygous. Accordingly, when two such plants are used as parents and crossed, the distribution of genes in the resulting seed will follow the lines given in the tabular example. Here it is important to note that only 4 out of 16, or $\frac{1}{4}$ of the progeny will be completely heterozygous for 2 characters and hence retain the vigour of their parents. However, many more than 2 characters are likely to be associated with vigour. In general the proportion of progeny having the same degree of heterozygosity, and hence vigour, is $(\frac{1}{2})^n$, where n is the number of characters or pairs of genes involved. Thus, even if only 5 pairs of genes are concerned with vigour, only 1 in 32 of the plants in the progeny will possess the same amount of vigour as their parents.

The very small proportion of desirable progeny that may be expected when vegetative clones are crossed thus provides an explanation of the unsuitability of this type of material for clonal seed production.

However, the production of improved clonal seed is still a feasible proposition, provided that the potential parents are correctly chosen. If we look back at our first example it will be seen that when a homozygous red flowered plant is crossed with a homozygous white flowered plant the progeny consists entirely of heterozygous pink flowered plants. Hence what is required is that our two clonal seed parents should both be highly homozygous, but carrying dissimilar genes. When crossed such plants must produce highly heterozygous offspring, which should display the required vigour.

However, this is not the whole story, since besides vigour our clonal seed must also exhibit other desirable characters such as good manufacturing quality. Accordingly in choosing our prospective parents it is essential to ensure that these desired characters are already present in one or both of them.

Unfortunately, owing to their lack of vigour, our required highly homozygous parents are likely to be rather poor specimens without any marked distinguishing features. In fact such plants are likely to be amongst those discarded in the seedling nursery and never planted out. Suitable parents are accordingly difficult to find. Furthermore, there is little chance of assessing their potentialities except by carrying out a laborious series of trial crosses, growing the progeny to bearing and then taking comparative yield and quality tests. Such a prospect is indeed formidable and any breeding programme may take very many years with little or no success except for the unexpected lucky chance.

Surely then it is far better to concentrate on the assured prospects of short term improvement offered by vegetative clones rather than to fritter away time and energy waiting for a lucky chance to provide us with two or more satisfactory generative clones.

SHADE REQUIREMENTS OF TEA IN NORTH INDIA

G. B. Portsmouth

The Annual Report of the Indian Tea Association Scientific Department for 1953 contains some interesting information concerning the various shade experiments now being carried out at Tocklai. Many of these experiments are complicated ones, being designed to explore the interactions of shade and manurial treatments, but in the present article only the effects of light intensity per se and in relation to the different species of shade trees commonly grown in North India will be considered.

An experiment of fundamental importance is one in which the light intensity reaching the bushes is artificially reduced by means of bamboo screens. Two types of screen are in use, both made from bamboo strips 1 inch wide and $\frac{1}{8}$ inch thick. One with 3 inch. wide spaces between the strips gives approximately 70 per cent. of full light intensity; the other with 2 inch. wide spaces gives approximately 50 per cent. of full light intensity. The screens are supported 6 feet above the tea on bamboo posts and frames.

The experiment is a big one comprising 96 plots in all. There are thus 32 plots receiving each of the three different light treatments, *i.e.* 100 per cent., 70 per cent. and 50 per cent. light. It is laid out on an area of tea planted at $4\frac{1}{2}' \times 4\frac{1}{2}'$ triangular in November, 1935 in area No. 8 of the Borbhetta Field Experimental Estate.

For the present experiment the bushes were pruned between 11-2-52 and 14-2-52 by leaving half an inch of new wood above the previous pruning level. After tipping at 8 inches, the bushes were then plucked weekly to the fish leaf from April till October.

The mean yields, in maunds (1 maund=80 lbs.) made tea per acre, for 1952, the first year of this experiment, are given in table 1.

Table 1. *Yields under Artificial Shade* **

Light intensity	Yield	Increase with shade
100%	6.35	—
70%	8.53	2.18
50%	8.18	1.83

** Taken from table on page 11 of Report.

Both these increases in yield obtained under reduced light intensities of 70 per cent. and 50 per cent. of full light are highly significant and fully confirm that, under North Indian conditions at any rate, tea requires shade to give its optimum yield. The difference in yields under 70 per cent. and 50 per cent. of full light is not, however, significant. This is helpful, as when shade is provided by trees, it is difficult to maintain the same density at all times. However, as will be seen later, the optimum light intensity is likely to vary for different kinds of shade and for different types of tea.

It may be noted that the increased yields in this experiment were obtained in the very first year of introduction of shade, which indicates that the effects of shade are both rapid and definite. Further results will be awaited with interest.

A rather more elaborate experiment, designed to study the effects of different species of shade trees, was started in 1939, when an area was planted up with 1-year old seedlings of an Assam type of tea. Two years later the area was divided up into hexagonal plots containing 108 bushes each and the centre bush of each plot replaced by one of the following species of shade trees:—

1. *Albizzia stipulata* (with Green stipules)
2. *Albizzia stipulata* (with Red stipules)
3. *Aleurites montana*
4. *Dalbergia assamica*
5. *Albizzia procera*
6. *Derris robusta*
7. *Albizzia odoratissima*
8. Control—no shade tree

There are sixteen repeats of each shade tree (divided amongst four different manurial treatments), so that the whole experiment comprises a total of 128 plots.

Using only half the available plots, (*i.e.* eight repeats of each shade treatment), light intensities were measured in foot candles by means of an exposure meter and recorded at intervals of approximately five weeks throughout 1952. The readings were taken at five points along the north—south diameter of each hexagonal plot on clear days between 10 a.m. and 3 p.m. In June 1952 the height of each individual shade tree was determined by means of a theodolite.

The plots were plucked weekly throughout the 1952 cropping season and the average yields obtained per plot, in pounds of green leaf, are given in Table 2.

Table 2. *Average light intensities, heights of shade trees and yields for* 1952**

Shade tree	Average light ft. candles	Average height of shade tree in feet	Average yield lbs.
Control—no shade	3339	—	160
Albizzia procera	2455	44	177
Albizzia stipulata (Green)	2420	36	177
Albizzia stipulata (Red)	2062	42	193
Dalbergia assamica	1989	46	179
Derris robusta	1938	38	181
Albizzia odoratissima	1853	53	207
Aleurites montana	1834	34	166

**Calculated from table on pages 14, 15 of Report.

With the exception of the plots under *Aleurites montana*, which is the only non-leguminous species under test, it can be seen that yields show a general tendency to increase with decreasing light intensities. This experiment therefore also confirms the necessity for some degree of natural shade, if the highest yields are to be secured.

Owing to the very large differences in growth made by individual trees of the same species, the relationship between yield, average light intensity and the height of the shade tree is not obvious from the figures given in Table 2. Accordingly an analysis was carried out in which the specific differences between trees were disregarded and the average effect of shade per se determined. This showed that:—

'For each foot increase in the height of shade trees, yield increased by 1.549 pounds of green leaf per plot of 108 bushes and the light intensity decreased by 15.0444 foot candles'.

Though indicating clearly the general trends which may be expected under shade, the figures quoted above are, of course, only applicable to the conditions of this particular experiment.

Even with an ideal lie of land, such as that utilised for the present experiment, there still remain many difficulties in interpreting the effects of natural shade. Thus it was found that the control plots had received some benefit of shade from the adjoining plots. Similarly, now vacant plots had received benefit in past years from the then standing shade trees, although light intensities recorded in 1952 were high. However, when the records from all such plots were excluded from the analysis, it was found that optimum yields were secured within the range of light intensities between about 1,200 to 2,200 foot candles, which was approximately between 33 per cent. and 60 per cent. of full light. The maximum yields appeared to be obtained at about 50 per cent. of full light.

Definite figures such as the above for the optimum light requirements of tea under natural shade must, however, be treated with caution. They have been determined from observations made on a few trees only and it is very likely that when large areas under a pure or mixed shade are observed the actual light intensities recorded in relation to the heights of shade trees and to maximum yields may be quite different. The extension of this work to an estate scale would thus appear to be necessary before detailed recommendations are possible.

The same experiment has also been made use of to compare the relative efficiencies of the different species of shade trees. This was done by discontinuing nitrogen manuring on certain of the plots from 1948 onwards. The annual yields from 1946 for tea under the different species of shade trees are given in table 3.

Table 3. *Annual yields in maunds of made tea per acre* **

Species of shade trees	Year	1946	1947	1948	1949	1950	1951	1952
	Nitrogen per acre	80 lbs.	80 lbs.	Nil	Nil	Nil	Nil	Nil
No shade tree		19.74	16.24	18.74	17.06	15.18	10.52	8.65
Aleurites montana		18.77	16.76	17.96	17.35	15.75	10.62	8.98
Albizzia stipulata (Red)		20.46	18.46	21.69*	20.41*	17.39*	12.48*	10.52*
Albizzia stipulata (Green)		20.60	18.82	21.79*	19.96*	17.06*	12.25*	10.14*
Albizzia odoratissima		20.39	18.92	20.34*	19.94*	17.43*	12.27*	10.60*
Albizzia procera		19.20	17.02	19.27	18.36	15.83	11.07	9.72*
Derris robusta		19.74	16.89	19.56	18.94*	16.84*	12.03*	10.20*
Dalbergia assamica		19.74	16.73	18.72	17.92	15.58	10.98	9.46
Significant Difference required at 5% level		1.33	1.73	1.45	1.49	1.57	1.22	0.93

* indicates significantly higher yields than under no shade.

** Taken from table on page 22 of Report.

In discussing these results the report presents the following conclusions:—

1. '*Albizzia stipulata* (Green), *Albizzia stipulata* (Red) and *Albizzia odoratissima* are the three most efficient trees amongst the ones used in this experiment.

2. Benefit from the application of sulphate of ammonia remains till the year after application of the manure both in shaded and unshaded tea.

3. Some of the benefit, can be observed for an extra year in tea that is under a more efficient species of shade tree.

4. Tea under the leguminous, nitrogen-fixing, species of shade trees used, benefits from their shade, but the time taken to become efficient varies inversely with the efficiency of the trees *i.e.* a tree low efficiency takes longer to produce its benefit to the tea.

5. *Dalbergia assamica* is a tree of low efficiency, but the indications are present that if left long enough, the tea under it may produce significantly higher yields than tea without any shade trees.

The low efficiency may be explained by the fact that this tree remains leafless for nearly six months in the year and thus is not a very useful shade-giving tree.

6. *Aleurites montana*, the only non-leguminous tree used in this experiment, is not benefitting the tea at all, as the yield of the tea under this tree has always been about the same as the tea with no shade.

This is possibly because such benefit as the tea under this shade receives is being offset by the fact that the tree is drawing all its nutrients from the soil without fixing any nitrogen from the air.

This finding does not support the view held by some, that any tree which gives shade is good enough. In the opinion of the writer, such trees may be of use only if extra manure is supplied to these trees, but that would be an unnecessarily wasteful method'.

Reading the above it would appear that much of the benefit derived from the more efficient species of shade trees is attributed to nitrogen fixation. However on referring to Table 3 it will be seen that the increases in yield secured under natural shade are of the same order as those secured under artificial shade and given in Table 1. The question as to whether the benefits of natural shade are due merely to a reduction in light intensity, to extra nitrogen produced by fixation, or to a combination of both effects would thus appear to be still unsolved. However, the fact that tea, under North Indian conditions, requires some degree of shade to give optimum yields has been proved beyond doubt by these experiments.

MAGNESIUM AND MANGANESE DEFICIENCIES IN THE NUTRITION OF THE TEA BUSH

J. A. H. Tolhurst

In an article in the preceding issue of the *Tea Quarterly*[1] mention was made of the need to consider the part played by less commonly considered nutrients in the growth of tea. The subject was deliberately left vague as at the time of publication work on certain nutrients was still in the early stages. Results concerning magnesium and manganese deficiencies in tea have now been obtained which are of sufficient interest and value to be published in the *Tea Quarterly*. More detailed scientific accounts will be published when the work is co mpleted.

While at Long Ashton Research Station the author had experience in a department which specialised in the diagnosis of nutrient imbalance in plants by means of 'visual foliar symptoms'. The basis of this method relies on the assumption that if a plant is suffering from an acute deficiency, or sometimes an excess, of one particular nutrient then the leaf shows a discolouration or deformity, or both, which is characteristic for that nutrient and for no other. Such symptoms, when they are known to be fool-proof, can be very simple aids to our investigations of the health of crop plants, but they are in the nature of an ultimatum since they show that the plant has been suffering for some time previously and is now reaching the stage of decline.

It must be obvious that a variety of causes can give rise to most peculiar deviations from the normal colour, size, shape and texture of a plant leaf or shoot. Climatic conditions and pests and diseases can be complicating factors, and there seems to be a tendency for many tea bushes to show odd branches with bright yellow or white blotches slapped haphazard on the leaves, or with a very sharply defined yellow rim round the leaf. These are almost certainly not nutritional or pathogenic, whatever their cause may be. A nutritional symptom follows a symmetrical pattern, often within a framework imposed by the leaf veins, which is the type shown by magnesium and manganese deficiencies in tea.

A more serious consideration is, whether a particular symptom is really characteristic for a deficiency of one nutrient only. With some crops, *e.g.* cereals and grasses, it is difficult to distinguish the various symptoms. With others, *e.g.* apple, citrus, avocado and probably cocoa, the individual symptoms are excellent guides to nutritional disorders. It now seems that tea can be classed as a good indicator plant.

Sulphur and potassium deficiency symptoms in tea have been thoroughly proved. Sulphur in Nyasaland many years ago, and potassium more recently in Java[2] and again in Ceylon.[3] In addition to the two symptoms recorded in this article the writer has observed another, very distinct, yellow pattern on the young tea shoots which have greened up when sprayed with an iron sulphate solution. Iron nutrition of plants is a rather complex subject and all that can be said of this symptom is that it represents a form of iron deficiency in the leaf, since there is no other information in the literature on tea to act as a guide.

Before describing the symptoms for magnesium and manganese it is of practical importance to digress on the use of foliage spraying as a means of correcting nutritional disorders in tea. Many plants are capable of absorbing nutrients which are

sprayed on to their leaves in a suitable form. The method is rapid in effect, economical in amount of nutrient required and often the only practicable way of curing certain deficiencies. It is not recommended to try to substitute foliage spraying for the normal manurial programme. As a further word or two of warning, get scientific advice on the compounds to use, and always use a wetting agent. The two deficiences to be described were diagnosed by the symptom shown on the leaf and confirmed by the improvement in leaf colour and growth following sprays containing the respective deficient nutrient.

Magnesium Deficiency.—Bushes in an area where growth was thin in spite of adequate general manuring were seen to have a discolouration on the older leaves which resembled that on Camellia varieties which the author had seen in a well known magnesium deficient area in the United Kingdom.

Apart from poor growth the main points of note were the dullness and brittleness of the old leaves with, in some bushes, a pronounced folding upwards along the mid-rib. The leaves were not much reduced in size. The colour was pale and without the dark bluish green seen in a healthy leaf.

The most characteristic symptom, however, was a diffuse yellowish brown to coffee coloured mottling which appeared as a vague mosaic between the main veins and towards the centre of the leaf. Individual bushes vary in details, but the general similarity of the symptom is apparent. The brown areas have never been seen to reach either the mid-rib or the leaf edge, or to cross one of the main veins.

It is not proposed to give chemical analyses at this stage, as there are connections with certain conditions in the soil and it has not been possible to begin these further analyses at the present. Magnesium analyses on the leaves of bushes used for diagnosis do, however, confirm that the symptoms described are those of magnesium deficiency.

The only other reference in the literature on this subject is from Java [2] where symptoms were induced in sand culture experiments, and a curiously casual mention made of low magnesium on certain estates. Whether the low magnesium caused serious effects in the field is not clear.

So far two widely separated areas have been found with severe magnesium symptoms associated with poor growth in the tea, and in a third area, where magnesium deficiency was detected and cured in citrus trees, suspected symptoms have been seen in the nearby tea.

For a more practicable control there are convenient magnesium containing manures, magnesium sulphate being very soluble and dolomitic limestone very slowly soluble. Trials with these have been started but the results will not be available for a little while. The sprays used in the above work were 2 per cent. magnesium sulphate, with a wetting agent.

Manganese Deficiency.—Again, the deficiency was diagnosed by the resemblance of a yellow pattern to that shown by certain other plants deficient in manganese, and again confirmed by the recovery after spraying, this time with manganese sulphate, and by chemical analysis of the leaf. In this case, however, it is the first instance of manganese deficiency recorded for tea under any circumstances.

In contrast to magnesium deficiency, the yellow pattern occurs on both young and old leaf, which remains dark green and glossy, except for bright greenish yellow 'tongues' between the main veins and in severe cases a narrow yellow band at the leaf edge. The yellow areas have a jig-saw outline and are fairly sharply defined.

Flush on these isolated bushes had slowed down markedly, and the leaves were small, dark and hard.

The cause of the deficiency was the burning of weeds on paths on a certain estate, with the result that the bushes nearest to the fires had a very heavy dose of an alkaline ash. The pH of the soil had been raised above 6.0, and this had been sufficient to render the manganese in the soil unavailable to the tea bush. This is a well known phenomenon in many crops, and the level to which the pH must be raised before the manganese is locked up depends rather on the amount of manganese in the soil. A pH above 6.0 will not, therefore, necessarily mean the tea bush is deficient in manganese.

In this instance it was suspected that the soil might be rather lower in manganese than are many of our tea soils, as the pH had only to be raised to 6.1 for a bush to be severely affected by the shortage of manganese. Again, soil analyses are not yet available, but preliminary leaf analyses show that the surrounding healthy bushes had much less manganese than bushes from several other estates. The possibility that their growth might benefit by addition of manganese is being investigated.

Apart from the possible practical implications there is an important point to note with regard to the confirmation by foliage spraying. This is a case where foliage spraying is the only practicable remedy, since the lowering of soil pH is an extremely difficult task and the addition of manganese salts to an 'alkaline' soil would only result in that manganese being locked up also. Manganese sulphate at 0.2 per cent. strength, plus a wetting agent, restored good growth and colour after only one spraying.

It is not inferred that the treatment of a few bushes is a practical necessity, but the possibility of other soils being low in manganese to the point of depressing bush growth should not be ignored.

This article has been written at an early stage in the work partly to emphasise the ideas of deficiency symptoms and the importance of lesser known nutrients, which are essential for healthy growth, and partly to induce planters to keep an eye open for unusual leaf colours. It is not possible for the writer to make an extensive estate survey, and the fact that several interesting, and sometimes important, indications of nutritional disorders have already been found on the few estates so far visited suggests that more of these deficiencies may easily be lurking in 'problem patches'.

We should welcome samples of leaves or shoots which look peculiar, but they should be sent in damp packing as such leaves often decay far more quickly than normal leaves.

It is unfortunate that inclusion of colour plates has been delayed, for technical reasons, as written descripton is very inadequate for deficiency symptoms. We hope to be able to remedy the omission shortly, and possibly to include illustrations of other deficiencies.

References

(1) Lamb, J. and Tolhurst, J. A. H.—*Tea Quarterly*, 1954, XXV., Pt. III, p. 51.

(2) de Haan, I.—Archief Voor de Theecultuur, 1941, XV., No. 1, p. 1.

(3) Portsmouth, G. B.—*Tea Quarterly*, 1953, XXIV., Pt. IV., p. 79.

WITHERING BY HEATED AIR

E. L. Keegel

Considerable attention is now being given to the increase in the capacity of withering fans in tea factories but very little appears to be paid to the amount of heated air available from the driers. Methods of using fans and hot air are still mostly carried out by rule of thumb; the connection between the volume of air delivered by the driers and that by the fans is seldom or never taken into account. Neither is the economy resulting from running an empty drier at a high temperature seriously considered. An understanding of some of the principles involved is therefore essential if the best possible results are to be obtained from the bulking of hot air from driers and cold air from the atmosphere.

In studying the various changes that take place when air is heated, cooled or mixed it must be remembered that barometric pressure has to be taken into consideration, because the density of air varies with altitude. For withering computations, however, precise results are not required and what follows is only an illustration of the manner in which the properties of air vary under the conditions normally experienced in artifical withering.

In order to follow these psychrometric changes in a tea factory it is first necessary to know a few fundamental rules. These are given below with examples.

(1) **Wet bulb temperature:**—When air is heated the wet bulb temperature also rises but in some definite relation to the increase in the dry bulb temperature and the moisture content of the air.

Example:— Table 1.

Air at temp. °F.		Heated to	Final wet bulb temp. °F.
Dry	*Wet*		
65	63	80 (dry)	68
,,	,,	160 ,,	88
,,	,,	190 ,,	93
70	66	190 ,,	94
80	71	190 ,,	95

(2) **Relative humidity:**—Heating of air does not alter its moisture content, but its relative humidity is lowered. In other words its capacity for taking up moisture is increased.

Example:— Table 2.

Air at temp. °F.		Relative Humidity	Moisture content per 1000 c. ft.	Extra water 1000 c. ft. of air can take up at the existing dry bulb temperature
Dry	*Wet*			
(*a*) 65	63	90%	0.88 lbs. water	0.10 lbs. (approx.)
(*b*) same air heated to 190° (Dry); 93° (Wet)		3%	,,	23 lbs. (,,)

(3) **Absorption of moisture:**—When air takes up moisture its *dry bulb temperature drops*, but the *wet bulb temperature remains constant*. This is what happens in a tea drier or withering loft. The drop in temperature depends on the amount of moisture absorbed. Saturation is obtained when the dry bulb temperature has dropped to the wet bulb temperature. It will thus be seen that the maximum amount of water a certain quantity of air can take up without addition of heat corresponds to saturation at *wet bulb temperature.*

The evaporative capacity of air is, therefore, not, as it is sometimes understood to be, the figure given in column 4 of Table 2. It is actually much less, as the following figures show:—

Table 3.

(Actual evaporative capacity of air)

Air at temp. °F		Extra water 1000 c. ft. of air can take up to reach saturation
Dry	*Wet*	
(*a*) 65	63	0.03 lbs. (approx.)
(*b*) same air heated to 190° (Dry):	93°(Wet)	1½ ,, (,,)

There should be no difficulty in understanding the difference between the two sets of figures given in Tables 2 and 3 so long as it is remembered that whereas the former refers to saturation at dry bulb temperature the latter deals with saturation at wet bulb temperatures. The distinction should be clearly understood because of its application to the drying and withering of tea.

(4) **Cooling by absorption of water:**—The drop in the dry bulb temperature after air has been used for drying or withering is explained by the foregoing remarks. The greater the amount of moisture taken up by the air the bigger the fall in the dry bulb temperature. At ordinary temperatures, the absorption of only 0.1 lbs. of water per 1,000 cubic feet is sufficient to lower the dry bulb temperature approximately 6°F. At high temperatures, the fall in the dry bulb temperature is slightly greater and for the same absorption of moisture is nearly 7°F.

In theory, therefore, the passage of air through a drier operated at say 190°F (inlet) and 130°F (exhaust) results in the air absorbing 0.85 lbs. of moisture per 1,000 cubic feet. Actually, it is less since the drop in temperature of 60° is not entirely due to moisture absorption. If radiation losses are accounted for and corrections made for the change in the density of the air, it will be found that under normal firing conditions the evaporation is equivalent to a little over ½ lb. of moisture per 1,000 cubic feet.

(5) **Cooling by abstraction of heat:**—When air is cooled by this method, both the dry-bulb and wet-bulb temperatures are lowered, till dew point is reached after which point if further cooling takes place surplus moisture is condensed. This phenomenon has been actually observed in some factories and is usually brought about by the employment of air at a high dew point. If the temperature outside is low, and insulation poor a considerable amount of heat is abstracted from the air in a loft. In the early stages of withering, especially when leaf is wet, the evaporation is so rapid that the air is almost saturated. If 100 per cent. saturated the dew point becomes that of the wet-bulb temperature, and any subsequent cooling causes condensation.

It must be remembered that dew point is entirely dependant on the moisture content of the air. For example, air at 65°F (dry) 63° (wet) has the same dew point temperature of 62°F (approx.) as air at 80° (D), 68° (W) or air at 190° (D), 93° (W). The exhaust air of a drier while in use for the drying of tea has a much higher moisture content and its dew point is therefore higher. That of air at 125°F (D), 93° (W) is nearly 85°F.

(6) **Mixture of air—dry bulb temperature:**—When air quantities at two different dry bulb temperatures are mixed, the dry bulb temperature of the mixture depends on the proportions in which they are mixed together.

Example:—Air at 160°F mixed with air at 60°F.

If in equal proportions the temperature of the mixture is

$$\frac{160+60}{2} = 110°$$

If in the proportion of 1 to 10, the temperature of the mixture is

$$\frac{(1\times160) + (10\times60)}{1 + 10} = 69°$$

Air at	mixed with	*Air at*	*in proportion*	*Temperature of mixture.*
190°F		60°F	1 to 10	72°F
120°F		70°F	1 to 10	75°F

(7) **Mixture of air—wet bulb temperature:**—The wet bulb temperature of a mixture is not so easily calculated since this depends on the moisture contents of the two quantities of air that are mixed together. The aid of a psychrometric chart has to be resorted to.

The following Table 4, calculated from a psychrometric chart, may serve as a guide for estimating the temperature in a withering loft when mixing hot and cold air in different proportions.

The dew point of the mixture and percentage relative humidity are also given as a matter of interest.

Table 4.

A. *Hot air from a drier NOT being used for firing of tea.*

Temperatures °F			Mixed in proportion of	Mixture			
Hot air.	Cold air. D.B.	W.B.		Temperature D.B.	W.B.	Dew Point	% Relative Humidity (approx.)
160	65	63	1 to 5	81	68	62	50
,,	,,	,,	1 to 10	74	66	62	65
,,	,,	,,	1 to 15	71	65	62	70
,,	75	71	1 to 5	89	75	69	50
,,	,,	,,	1 to 10	83	73	69	65
,,	,,	,,	1 to 15	80	72	69	70
190	65	63	1 to 5	86	70	62	45
,,	,,	,,	1 to 10	76	67	62	60
,,	,,	,,	1 to 15	73	66	62	70
,,	75	71	1 to 5	94	76	69	45
,,	,,	,,	1 to 10	85	74	69	60
,,	,,	,,	1 to 15	82	73	69	70
B. *Hot air from the drier exhaust while tea is being fired.*							
125	65	63	1 to 5	75	70	67°	75
,,	,,	,,	1 to 10	70	66	65°	80
,,	,,	,,	1 to 15	69	66	64°	85
,,	75	71	1 to 5	83	76	74°	70
,,	,,	,,	1 to 10	80	74	72°	75
,,	,,	,,	1 to 15	78	73	71°	80

In practice indentical results are unlikely to be obtained but from the data provided information is available concerning the conditions under which a withering system can best be employed. A large proportion of the methods now used are crude and empirical; further some of the present withering systems leave much to be desired and if the principles of air-conditioning were properly understood a higher degree of success could be achieved.

One fundamental fact stands out from these data and it is that the exhaust air from a drier, has, contrary to popular belief, further drying capacity. Although it contains the additional moisture picked up from the leaf during drying, it can be usefully employed for withering. But it may be readily seen from table 4 that the amount of cold air that has to be mixed with the exhaust air to provide sufficient drying capacity is much less than that required for an empty drier. It is obvious, therefore, that the valuable heat from drier exhaust will be wasted by indiscriminately letting in too much cold air.

A further study of the figures in table 4 also reveals the following information.

(*a*) No matter what outside temperature conditions exist or at what temperature the drier is run, an increase of about 10°F in the dry bulb temperature is sufficient to give conditions suited for withering purposes.

(*b*) The drying capacity of the mixture is influenced to a much greater extent by the amount of outside air admitted than the temperature of the hot air.

(*c*) If the capacity of the withering fans is more than 15 times that of the drier and they are worked at their maximum efficiency the hygrometric difference of the conditioned air may at times be lower than the figure of 7°F generally accepted.

(*d*) The wet bulb temperature of a mixture of outside air and hot air from an empty drier rises approximately 1° for every 3 to 4° increase in the dry bulb temperature.

This relationship does not hold true when the exhaust air from a drier is used.

In the light of the foregoing information and the knowledge that the dry bulb temperature drops when air takes up moisture it is not difficult to understand why a minimum hygrometric difference of 7°F is recommended in artificial withering. It is therefore, obvious that the smaller the volume of air delivered into a loft the bigger should be the hygrometric difference and vice versa. It is uneconomical of course to have too large a volume of air with too small a wet bulb depression. In any case, the amount of air is limited to some extent by the speed at which it travels through a loft. Neither is a low volume of air satisfactory because apart from the fact that there will be very little air movement the temperature will have to be raised unduly to give the necessary drying capacity.

It is evident, therefore, that temperature is not the most important consideration in artificial withering. The amount of air available is equally important and it would appear that many factories to-day possess inadequate fan capacity. This probably explains the increasing tendency to employ high temperatures in withering. The figures given in table 5 may be used to estimate fan requirements in relation to crop and size of drier.

Table 5

Drier for withering	Total fan capacity (cu. ft. per min.)	No. of bulking chambers	Average daily green leaf in-take	Annual crop. (made tea)
3′	50,000 to 80,000	1	5,000 lbs.	300,000 lbs.
4′	80,000 to 120,000	1	8,000 ,,	500,000 ,,
5′	120,000 to 180,000	1 or 2	12,000 ,,	750,000 ,,
6′	160,000 to 240,000	1	16,000 ,,	1,000,000 ,,

It must not be concluded that more fan capacity is not desirable but anything lower is certainly inadequate. If the capacities of fans and driers are so related as given in Table 5, no difficulty should be experienced, even under adverse monsoonal conditions, in getting a reasonable hygrometric difference in the conditioned air. There is no necessity for high temperatures to get a mixture of suitable drying capacity when sufficient fan capacity is available.

One limiting factor in increasing the size or speed of fans is of course the velocity of air flow through one single loft. But this is not so serious as it is made out to be. If air speeds are so high as to blow leaf off the tats, the bank nearest the bulking chamber can be kept free. In the alternative, a part of the air can be diverted into an empty loft, or all of it reversed into the section containing the leaf; or for that matter, only one fan can be operated.

It is strange, however, that no attempt has yet been made to provide variable speed fans to meet contingencies as the one just mentioned or when crops are low. Such a scheme will not only make control of the withering process easier but will also save power. The delivery of air from the fans could then be varied according to crop, and in this way the loss of heat, due to excess air, uncontrollable on the present systems, could be reduced to a minimum.

While on the subject of heated air for withering it may be well to consider the measures to be taken to secure the most satisfactory results. No hard and fast rules can be set down because of the numerous variable factors. The following practical hints, however, may prove helpful to those factories where the process is being haphazardly carried out.

(1) Although the efficiency of most of the present schemes has been considerably improved by boosting the air and reversing it, thicker spreading of leaf nearer the bulking chamber is strongly recommended.

(2) Spreading of wet leaf should always start furthest from the bulking chamber.

(3) The loft should always be warmed before wet leaf is spread.

(4) The highest possible temperature should be used for removal of surface moisture. Many observers recommend large hygrometric differences for this purpose, but it is quite apparent from Table 4 that in practice they cannot be obtained. Generally, the driers are being used for the firing of tea at the times wet leaf is received and the only source of heat is the drier exhaust. To obtain the maximum temperature the minimum amount of cold air must be admitted but care must be taken in doing so to see that the fans are not too scantily supplied with air. A part of their demands in such circumstances might be met from the driers themselves causing erratic firing.

(5) Hygrometers are necessary for control but they should be placed in the correct places, not in the middle of a loft or behind a bank of tats, as is customarily done. That recording the temperature of the inlet should be in front of the first bank and the one at the exit end directly opposite the window through which the air is discharged.

When air is led from one loft to another below or above it the hygrometer should be placed behind the last bank of tats. If the hygrometric difference is found to be less than 3°F after it has passed over the leaf little will be gained by passing it through another loft. If after traversing two lofts or more, air is discharged into the atmosphere with a hygrometric difference of over 4°F excess heat is just being wasted.

(6) If the capacity of fans is found to be inadequate the air used for artificial withering should have a hygrometric difference greater than 7°F. A 10°F wet bulb depression or even more is possible without having to raise the dry bulb temperature beyond a point where quality is likely to be seriously impaired.

(7) In a factory possessing adequate fan capacity there should be no difficulty in creating conditions at night approaching natural conditions in the day time. By a suitable adjustment of drier temperature and airflow through the drier, the maintenance of temperatures not exceeding 75°F(dry) with a satisfactory wet bulb depression is not at all a formidable task.

(8) A higher drier temperature with less air is more economical than a lower temperature and more air. Every effort should therefore be made whenever circumstances permit, to run an empty drier when used for artificial withering at the highest possible temperature, using the fan-damper to regulate the temperature of the mixture of the air in the lofts. This is an easier and more economical form of control than the empirical method of shutting and closing windows opposite the fans or in the drying room.

(9) Just as important as allowing sufficient openings for air to leave the lofts it is equally necessary not to starve the fans. The area of air entry should not be less than the area of the fan inlet. Table 6 gives the minimum free area required for fans of different sizes.

Table 6.

Diameter of fans	Minimum area for 2 fans.
6′	60 sq. ft.
7′	80 „ „
8′	100 „ „
9′	130 „ „

It is not intended in this article to discuss the wider aspects of artificial withering. The main purpose has been to give an insight into a process which would appear to be the one least understood in tea manufacture. There is a common notion for instance that a hygrometric difference of over 6-7°F in withering is harmful. Another view that has no foundation is that natural withers cannot be obtained in a reasonable time if the hygrometric difference is lower. In consequence, artificial withering has become a habit in most estates. The poorer results that followed from the indiscriminate use of heated air naturally gave rise to the erroneously held belief that artificial withering is an evil. Without question, a natural wither does give better results provided the period is not unduly lengthened, but for a greater part of the year the use of heated air is a necessity in some factories. It is hoped these notes will enable better results to be obtained from a process against which a deep-rooted prejudice still exists.

Photo by B. N. Webster

THE 'KAYBEE' INFRA-RED MOISTURE TESTER TYPE X-14

E. L. Keegel

This is an instrument which depends for its operation on the heat from infra-red light. As the accompanying photograph shows, it is very simple in construction, consisting of an infra-red lamp and a pendulum balance, one end of which holds a pan. The material to be tested is placed in the pan and, on exposure to the radiations from the lamp, rapidly loses its moisture. A pointer on the balance, which moves over a scale graduated 0-30 per cent., indicates the percentage moisture content of the sample.

It will be seen, therefore, that no weights have to be used. Those provided are meant only for checking the instrument from time to time. The procedure for a moisture determination is to load the pan with the sample until the pointer is at zero, switch on the 150 watt infra-red lamp and note the reading on the scale after a specified time for a certain setting of the lamp. Slots enable the height of the lamp above the sample to be varied.

Numerous tests were carried out with tea varying in moisture content from 1 to 10 per cent., particular attention being paid to the performance of the instrument when dealing with samples at moisture levels between 2 and 6 per cent.

Drying period.—The design and principle of the infra-red tester is such that the time necessary for a sample to reach its true moisture content figure varies with its original moisture content, and the height of the lamp above the sample.

If, therefore, the instrument is to function for a fixed drying period it has to be calibrated for a certain height of the lamp. The most suitable drying time will have to be one which will not cause burning of a sample having a very low moisture content. From numerous determinations it was found that with the lamp set at the highest and lowest positions the maximum period permissible was 10 minutes and 7 minutes respectively.

Calibration.—The instrument was accordingly calibrated for these respective periods by comparing the reading on the scale corresponding to each sample against the moisture content obtained by the standard steam oven method.

There was very little to choose between the two positions of the lamp. However, considering that there is some risk of a sample charring, say in a dry atmosphere, by the use of the lamp at its lowest position, it was decided to make the final calibration with the lamp set in slot 5 (highest position) and a drying period of 10 minutes.

The curve of closest fit was drawn by plotting all the figures obtained on a graph. From this calibration curve the following Table (1) has been drawn up and will be found to be more convenient for actual use;—

Table 1

Reading on scale	*Nearest true moisture content*
1.0	0.4
1.5	1.0
2.0	1.6
2.5	2.2
3.0	2.8
3.5	3.4
4.0	4.0
4.5	4.6
5.0	5.2
5.5	5.8
6.0	6.4
6.5	7.0
7.0	7.6
7.5	8.2
8.0	8.8
8.5	9.4
9.0	10.0

Accuracy.—Although the normal range of moisture in made tea is small an absolutely accurate value is not essential. For all practical purposes a difference of half per cent. moisture is of no significance. At high moisture content levels of over 7 per cent. a difference of even 1 per cent. is immaterial.

A close examination of the foregoing table reveals that, for the range of 3 to 5 per cent., the most important in tea manufacture, the instrument is accurate to within $\pm$ 0.2 per cent. Below 3 per cent. the meter gives readings approximately 0.5 per cent. more than the true moisture content. And in the range 5 to 10 per cent the deviation is greater. Yet the differences do not exceed the tolerances mentioned. A direct reading off the scale may, therefore, be taken as the moisture content of a sample. However, where a higher degree of accuracy is desired, it is recommended that the calibration figures given be adopted. Briefly, the correction to be made is as follows:—

Reading on scale	*Correction*
Between 1 and 2	Subtract $\frac{1}{2}$ per cent.
,, 2 and 5	No correction
,, 5 and 7	Add $\frac{1}{2}$ per cent.
,, 7 and 10	Add 1 per cent.

For still more accurate work the exact position of the pointer between the divisions can be easily gauged by means of an ordinary magnifying lens. In this way it is possible to take readings to 0.2 per cent.

Reliability.—This was tested by a complete series of new readings taken on different samples. The corrected figures were obtained from the calibration curve plotted and checked against the true moisture contents. Nearly 50 samples of all descriptions of tea were dealt with. The difference between the interpreted values of moisture contents and the true moisture contents was never greater than half per cent. The error is of such a small order that the reliability of this instrument compares favourably with that of a steam oven.

Possible sources of error :

(1) Variation in the humidity of the atmosphere.
(2) Variation in the size of the sample.
(3) Variation in the composition of the sample, depending on the proportion of leaf to stalk.
(4) Uneven spreading of the sample in the pan.

None of the above mentioned factors is likely to introduce a perceptible error, but their influence could be reduced by the following measures:—

(*a*) Operation of the instrument with the lamp set at the highest position.
(*b*) Levelling of the sample in the pan without compacting it under pressure.

Precautions.—To ensure good results and reduce all errors to negligible proportions it is important that:—

(1) The instrument be checked from time to time with the weights provided.

(2) It be placed in a draught-free and dust-free room.

(3) The part of the instrument which houses the knife edge and pendulum be enclosed in a case when not in use.

(4) The pointer be at rest and at the zero reading on the scale before the lamp is put on.

(5) The pan be cooled before each determination.

Conclusions.—The standard of performance of this instrument renders it most suitable for use in tea factories. It is easy to handle, simple in operation and offers a quick method for the determination of moisture in made tea with an accuracy approaching that of a steam oven.

The value of the instrument would, however, be enhanced if the scale was marked in terms of actual moisture content as determined by oven drying (vide Table 1) and in divisions of half per cent. moisture.

The instrument is available locally. The electric supply, whether alternating or direct current, and voltage, should be specified when ordering. The life of the infra-red bulb is stated to be a minimum of 800 hours, equivalent to about 5,000 moisture determinations. According to the suppliers its life may even be twice as long.

STARCH DEFICIENCY

A REVIEW OF ITS CAUSES AND EFFECTS WITH SPECIAL REFERENCES TO TYPES OF PRUNING IN THE LOW-COUNTRY

T. E. Walter

From recent observations on the types of pruning that are now being carried out in the low-country, it would appear that in many cases adequate attention is not being paid to the main principles which determine the type of pruning best suited to low elevations; in fact, cases are known of Superintendents who, on being transferred from up-country to a low-country estate, have transferred their ideas on pruning with them, and clean-pruned some of their fields, needless to say, with somewhat indifferent results! It has therefore been suggested that a review of the whole question of starch deficiency in the low-country,—and the relative problems in regard to pruning (as investigated by Dr. Tubbs)—would not be out of place.

The 'Diplodia' Disease.—The early publications of the Tea Research Institute show that formerly the widely exhibited complete or partial failure of tea bushes at low elevations to recover after pruning was attributed to a disease known as 'Diplodia'; in 1923 Petch ascribed this disease to the fungus *Botryodiplodia theobromae*, which was invariably found on the roots of such dead bushes.

Starch storage in relation to the 'Diplodia' disease.—In 1928 however, the important discovery was made that the roots of tea bushes store starch, and Gadd traced the connection between the incidence of 'Diplodia' disease and the amount of starch that was stored in the roots of attacked bushes. This placed the 'Diplodia' problem in an entirely new light, and exhaustive tests showed that the roots of bushes which had died after pruning were invariably devoid of starch; on the other hand, starch was present in the roots of healthy bushes, and those which had died as a result of infection by root disease fungi. He therefore came to the inevitable conclusion,—confirmed by subsequent reasearch work—that the primary cause of death of tea bushes after pruning was the lack of sufficient food reserves (*i.e.* starch) in the roots at pruning time to support recovery; the occurrence of *Botryodiplodia theobromae* on the roots of these bushes was therefore purely secondry, —its invariable presence being explained by the fact that it is one of the commonest fungi found in dead tissues of low carbohydrate content.

The role of starch in the economy of the tea bush.—Before going into any further detail, it is necessary to recall that starch is one of the principle carbohydrates formed in the process of photosynthesis, by which the leaves of plants in the presence of sunlight convert the raw materials obtained from the soil and air into elaborated food materials; these carbohydrates form the true food of all the higher plants, and their presence in plants is essential for growth; thus a periodic buildup of carbohydrates by photosynthesis is accompanied by their constant breakdown in the plants' growth processes.

This state of affairs assumes great significance in the case of a crop such as tea which is periodically pruned; for if tea bushes are left at such times almost devoid of leaves, they are unable to make use of the raw materials necessary for growth, and are inevitably dependent for recovery entirely on the reserves of elaborated foods (*i.e.* starch) which they may have accumulated.

The effect of elevation on starch storage.—Following on the initial iscovery that the problem of deaths of tea bushes after pruning was not a mycological ne, but was intimately bound up with the question of starch reserves in the bushes t pruning time, Tubbs made a series of further investigations on many aspects f the problem.

The first of these consisted of a survey of the relationship between elevation nd the amount of starch stored by the bushes. This indicated that the total arbohydrate content of bushes increased in direct proportion to the elevation, -bushes at sea level containing an average of 10 per cent. carbohydrate, and those t 7,000 feet an average of 26 per cent. Although these figures do not indicate recisely the amount of carbohydrate reserve that is actually available to the bushes for use in recovery after pruning), they are nevertheless of great significance, specially as it was found that the bushes which failed to recover from pruning nowed a total carbohydrate content of 12 per cent. or less. From this it was evident nat tea bushes when pruned must contain a reserve balance over this amount, or o new shoots would be produced, resulting in their partial or complete death.

Although differences in cultural treatment at various elevations—(in particular arying pruning cycle lengths)—may have some long term effect on the carbohydrate torage balance, the probable fundamental cause of the balances varying with levation is temperature differences, which exert a marked effect on the rate of uild-up and break-down of carbohydrates. Thus at low elevations the higher emperatures cause a considerable increase in the rate of carbohydrate manufacture, ut this is more than offset by an increase in their rate of break-down,—a process vhich moreover is continuous and not confined to daylight; in addition the higher oil temperatures tend to enhance the consumption of carbohydrates by the root issues. In other words, the greater call made on the carbohydrates at low elevations, ue to the enhanced growth rate, results in a reduction of their net daily balance *i.e.* amount of reserve) to a point at which it is insufficient to enable the bushes to evelop new growth after a severe prune.

On the other hand at high elevations, the slower rate of growth (*i.e.* a slower ate of break-down of carbohydrates) enables the bushes to build up a higher carbo-ydrate balance in their roots, which is adequate to enable them to recover from lean pruning.

It follows, therefore, that since the ability of bushes at low elevations to recover rom pruning is entirely dependant on the amount of carbohydrate stored in their oots, logical ways of ensuring recovery consist of the following:—

(1) Modifying the method of pruning adopted, with the object of ensuring that there are enough leaves left on the bushes at pruning time to enable them to continue to elaborate food materials, and:

(2) Suitable cultural operations before pruning, (such as adequate manuring, and resting of weak bushes as necessary), with the object of increasing the carbohydrate reserve.

The comparative effects of different types of pruning.—With the ackground to the problem of pruning at low elevations now elucidated it followed hat any form of cut-across prune would go far towards giving the desired result; he normal cut-across, however, has the inherent disadvantage that dead and diseased vood cannot be cleaned out, while there is a tendency to leave an inadequate number f leaves on the bushes. An entirely new type of pruning now suggested itself, descriptively termed 'rim-lung'—and a series of tests at different elevations was arried out to compare the results achieved by this method with those of the orthodox

'clean' prune, and 'cut-across' prune. Although in practice these were not completely distinct from each other, differences between them were nevertheless sufficiently wide to enable them to be classified roughly as follows:—

1. **Clean-prune.**—the main frame pruning branches being cut to 3" above the previous pruning level, and nearly all the smaller branches removed.

2. **Cut-across.**—pruned at the same level as for the clean prune, but nothing except diseased wood was removed below that level.

3. **Rim-lung.**—only the centre of the bushes were pruned, at the same level as the others, 6 branches being left on the circumference until 10 days before tipping.

As already stated, experiments with these types of pruning were replicated at various elevations typical of 'low-country', 'mid-country', and 'up-country'; for the purposes of this review, however, we are only concerned with the effects under low-country conditions—the relevant plots being sited on Galatura Estate, at an elevation of 200 feet.

Perhaps the most spectacular revelation of these experiments was the comparison between the numbers of deaths which occurred within 3 months of pruning, under the three systems. Each treatment comprised a total of 1,500 bushes and clean pruning resulted in the death of 67 of the bushes while rim-lung and cut-across prunes resulted in the deaths of 8 and 27 bushes respectively.

It should be added that the plots were chosen for uniformity and, therefore, for healthiness—from which it would be reasonable to assume that the percentage of deaths of the clean pruned bushes would have been far greater on the impoverished areas which are more representative of typical low-country tea.

The other information obtained from these plots is as follows:—

	Clean prune	*Rim-lung prune*	*Cut-across prune*
Die-back after pruning (lbs. of dead material per 1,500 bushes)	346 lbs.	130 lbs.	227 lbs.
No. of leaves remaining per bush after pruning	3	201	42
Average diameter of pruned bushes	2.7 ft.	3.5 ft.	3.3 ft.

It is clear that at low elevations, rim-lung is the most satisfactory type of pruning—at least with the systems of bush management adopted at that time, (i.e. when a low prune was in vogue). This method allows all the necessary 'bush sanitation' to be carried out, without any of the disadvantages inherent in clean pruning at low elevations; moreoever, its salutary effect on the spread of the bushes is of some importance.

The combined effect of all this was of course evident in the yields obtained under the 3 systems, and the plots which were rim-lung pruned showed a relative increase of over 200 lbs. per acre at the end of the first 2 year cycle.

Following on these experiments in which the 3 main types of pruning were compared, another experiment was carried out at Galatura, to compare the effects of the following:—

1. 6 lungs left on the bushes for 1—2 months from pruning.
2. 3 lungs left on the bushes „ „ „ „ „
3. Clean pruning.

The data from this experiment is summarised as follows:—

	6 lungs	*3 lungs*	*Clean prune*
Average number of leaves left per bush	327	203	3
Number of deaths per acre (3,000 bushes)	22.5	28.2	168.6
Lbs. of pre-tipping die-back per 1,000 bushes	110 lbs.	127 lbs.	237 lbs.

As would be expected, the greater rate of growth consequent on leaving 300 leaves per bush allows the lungs to be removed earlier than when only 200 leaves are left (in which case they should be left on until tipping time). The experiment also disproved the idea current in some quarters that the growth of the lungs was prejudicial to the production of tipping shoots in the centre of the bushes.

The final recommendation made as a result of all these experiments was that below 1,500 feet not less than 250 leaves per bush should be left at pruning time.

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MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD AT THE OFFICES OF THE PLANTERS' ASSOCIATION OF CEYLON, AT 2-30 P.M. ON FRIDAY, 1ST OCTOBER, 1954

Present:—Mr. R. C. Scott, C.B.E. (Chairman), Messrs. K. Morford, C.B.E. (Chairman, Planters' Association of Ceylon), D. F. Ewen, C.B.E. (Chairman, Agency Section, Planters' Association of Ceylon), T. E. D. Loftus, C.C.S. (Assistant Secretary, Ministry of Finance, representing the Minister of Finance), D. C. .,L Amarasinghe, C.C.S. (Tea Controller), A. J. Dickson, D. E. Hettiarachchi, J.P., U.M., H. S. Hurst, J. L. D. Peiris, R. M. Macintyre, B. Amarasuriya, W. H. Gourlay, C. D. Green and J. Lamb, O.B.E., J.P. (Director & Secretary).

By invitation: Col. J. A. T. Perera.

Also present: Messrs. G. A. D. Kehl and J. V. Harbord, T.R.I.

A letter regretting inability to attend was received from Dr. A. W. R. Joachim, O.B.E. (Director of Agriculture).

1. Notice convening the meeting was read.

2. **Minutes of Board Meeting held on 21st May, 1954**

The minutes were confirmed subject to the amendment notified to members in correction slip dated 21st September.

3. **Membership of the Board & Committees**

(a) Board

Representing the Low-Country Products Association.

Official confirmation was received of the nomination of Messrs. J. L. D. Peiris and B. Amarasuriya to fill the places vacated by Messrs. W. Neal de Alwis and Errol Jayawickreme with effect from 6th March, 1954.

Representing the Planters' Association of Ceylon, Agency Section.

Messrs. R. M. Macintyre and W. H. Gourlay were appointed to act for Messrs. G. K. Newton and A. D. McLeod as from 5th May, 1954, and 1st August, 1954, respectively.

Representing the Planters' Association of Ceylon.

It was reported that Mr. A. J. Dickson was retiring shortly. The Chairman thanked him on behalf of the Board for the valuable service he had rendered during his period of nomination.

(b) Finance Sub-Committee

It was reported that Sir Arthur Ranasinha had agreed to serve on the Committee.

The seat temporarily rendered vacant by the absence of Mr. A. D. McLeod was filled by the election of Mr. R. M. Macintyre.

4. **Finance**

(a) The Audited Accounts of the Institute for 1953 were considered. These had been discussed by the Finance Sub-Committee, which had accepted them with the following recommendation:—

> That the Colombo Commercial Co. should be approached through the auditors for a valuation of all assets for making a realistic and up-to-date Register of Assets.

The Board then adopted the accounts on the proposal of Mr. Hurst, seconded by Mr. Hettiarachchi.

(b) The Institute's Accounts as at 31st August, 1954, were considered and accepted.

(c) Investments. It was reported that

(i) Stock to the value of Rs. 100,000 was purchased in June for the Institute in the Ceylon Government $3\frac{1}{4}$ per cent. loan, 1964.

(ii) A further sum of Rs. 600,000 was placed on Fixed Deposits at 0.75 per cent. with the National Bank; Rs. 300,000 for 3 months and Rs. 300,000 for 6 months.

The Chairman thanked Messrs. Forbes & Walker for the advice and assistance received in this connection.

5. **Minutes of the Experimental & Estate Sub-Committee Meeting held on 19th June, 1954**

The proposals of the Sub-Committee were approved by the Board. Proposed by Mr. Dickson. Seconded by Mr. Hettiarachchi.

6. **Future Low-Country Activities**

The following recommendations, proposed by Mr. Gourlay, seconded by Mr. Hurst, were accepted:—

(i) That nothing should hinder the early establishment of the clonal proving station, but that at the same time the purchase of a suitable estate should be investigated.

(ii) That a Sub-Committee to handle the Board's low-country interests should be formed, consisting of the following members:—

Messrs. Pieris, Hettiarachchi, and Lamb. Mr. Bean as a co-opted member.

7. **Minutes of the Standing Committee of 18-6-54**

(a) Memorandum by Col. Perera on the establishment of a joint consultative committee on the Whitley pattern. Mr. Hurst questioned, and Col. Perera explained, the statutory responsibility of the Board on matters relating to employment, conditions of service, etc. Chief discussion centred round the composition of the Consultative Committee in connection with its senior members.

It was finally agreed that the Director be authorised to nominate a Chairman and the three senior members of the Committee.

Proposer — Mr. Amarasinghe
Seconder " — Mr. Green.

(b) Formation of a T.R.I. Sports Club.—The present use of the Norris Memorial Club was irregular. The Board agreed to appoint the Chairman and Director as Trustees of the building to draw up rules for its use as a recreational club for the senior and assistant staff of the Institute.

(*c*) Mr. Macintyre proposed and Mr. Amarasinghe seconded the approval of the remainder of the Standing Committee's minutes in toto. This was agreed.

8. Junior Staff Provident Fund & Medical Funds

(a) Provident Fund

The minutes of the meeting of the Trustees held on 17-6-54 were approved after deletion of the last sentence of paragraph 1 on page 2, and subject to the rejection of the recommendation 3(B) on page 1, and the amendment of 3(A) to read as follows:—

'That members of the staff on probation and future entrants be allowed to contribute to the provident fund from the date of thier joining the Institute'.

Proposer—Mr. Amarasinghe. Seconder Mr. Hettiarachchi.

(b) Medical Fund

The Minutes of the meeting of the Committee of Management held on 17-6-54 were approved.

9. Small Holdings Advisory Service

Additional Staff.—The appointment of five more Tea Instructors was approved.

Lease Bond of Headquarters.—The Board agreed to its seal being affixed to this document.

Staff Increments.—It was agreed to promote Mr. W. T. Fonseka, Senior Small Holdings Officer, to the selection grade at a salary of Rs. 575 per mensem as from 7-9-54.

10. Staff

Pathologist—Mr. C. A. Loos

Mr. Loos had returned to Ceylon from his scholarship in the U.S.A. on 15th August. He had been away for 2½ months and had during this period visited several research stations.

Engineer—Mr. J. Landreth

Mr. Landreth's resignation would take effect from 21st October, 1954. He had earned 3½ months leave since he had returned from his previous leave. He would therefore be due payment of salary up to 4th February, 1955, amounting to Rs. 9,554/65 in addition to the proportion of passage as approved at the last meeting.

Mr. Landreth had requested the Board to include the payment of the proportion of passage for his two sons, who were at present at school in Tasmania. This was approved.

Proposed by Mr. Dickson. Seconded by Mr. Green.

Entomologist—Dr. B. A. Baptist, B.Sc. (London), Ph.D. (Cantab.)

Three selected candidates, Dr. B. A. Baptist, Dr. H. E. Fernando and Mr. A. C. J. Weerakoon had been interviewed by the Appointments Sub-Committee at Peradeniya on 25th June, 1954. All members of the Board had agreed to the recommendation of the Sub-Committee to offer the post to Dr. Baptist on a starting salary of Rs. 1,500 in the scale Rs. 750-50-2,000 (cf. Circular No. A9/54 dated 30th June, 1954).

Dr. Baptist would take up duties on December 1st.

Technical Assistant to the Director—Mr. J. V. Harbord

Mr. Harbord had assumed duties on 1st June, 1954.

Application from Mr. M. S. Ramaswamy, Research Assistant

Mr. Ramaswamy had asked that he be granted an extension of the free railway warrants to cover journeys from Talawakelle to Bangalore (India), where his child was at school. He had failed to obtain a residence permit in order to have him schooled in Ceylon. Agreed.

Assistant to the Plant Physiologist—Mr. L. M. de W. Tillekeratne, B.Sc.

Mr. Tillekeratne had been appointed to fill the post left vacant by the resignation of Mr. E. S. Rajiah, who had resigned on 7th July, 1954, to take up an estate appointment. Mr. Tillekeratne had begun work that day.

Increments, Senior Staff

The undermentioned increments to staff were approved.

Mr. B. N. Webster (Mycologist) Rs. 62/50 as from 1st August.
„ E. L. Keegel (Technologist) Rs. 50/- as from 7th September.
„ R. L. Illankoon (Officer-in-charge, Small Holdings Advisory Service) Rs. 40/- as from 7th September.
„ T. E. Walter (Scientific Officer) Rs. 62/50 as from 1st November.

It was agreed that the Director need not in future seek Board approval for normal increments.

Proposed by Mr. Gourlay. Seconded by Mr. Green.

11. Any Other Business

Visit to South India by the Director. The Director accompanied by his wife had on an invitation from the United Planters' Association of South India proceeded to South India to attend their Annual General Meeting and Conference, which were held on the 23rd and 24th of August, 1954. He had taken the opportunity while in India to visit several tea estates.

Annual Report of the Board for 1953

All members of the Board had approved the publication of the Annual Report of the Board for 1953 as well as the audited accounts for 1953, vide Circular No. A13/54 dated 21st July, 1954.

Conference

The Director had suggested that the next Conference of the Institute should be held on Friday and Saturday, 25th and 26th February, 1955, and if a repeat was necessary on Friday and Saturday, 4th and 5th March, 1955. This was approved.

Director's Honour

Mr. Green asked that the congratulations of the Board to the Director on the award of his O.B.E. should be recorded.

The meeting terminated at 5-45 p.m.

J. LAMB,
Secretary.

Tea Research Institute of Ceylon,
St. Coombs,
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